Original Research Article

Effect of integrated nutrient management on growth, yield and quality~~and yield~~ in garlic (*Allium sativum* L.)

Abstract

Garlic has the charisma of a potent remedy and holds its repute of a therapeutic panacea since the dawn of civilization. So to increase its productivity and medicinal value integrated approach will be required.Allicin is the main bioactive compound, which is responsible for medicinal value produced by garlic. It is present in the bulb in the form of allin, which is converted to allicin when the bulb is cut or crushed.The ~~studies~~ study~~were~~ was conducted on garlic variety "Kandaghat Selection". The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications comprising of fourteen treatments was carried out at the Experimental farm of Horticulture Research and Training Station and KVK, Kandaghat, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP)during the rabiseason of 2018-19. Out of the fourteen treatments ~~treatment~~ comprising of 100% recommended dose of NPK + 50 kg S/ha + 5% Jv @ 1 L/ m^2 (T_7) recoded significantly higher plant height, number of leaves per plant, bulb weight, bulb diameter, number of cloves per bulb, bulb yield, dry mater content of bulb and TSS.Phytomedical evaluation by HPLC showed that all bulbs from all treatments are rich in allicin content and their recorded values were higher than pharmaceutical grade.

Key words: INM in garlic, Sulphur,Allicin,~~Effect of sulphur on quality of garlic~~, jeevamrit

Comment [w1]: The abstract should be re-written

Comment [w2]: Is it the only reason?

Comment [w3]: What does it mean?

INTRODUCTION

Garlic (*Allium sativum* L.) is ~~the~~ popularly grown *Allium* species after onion belonging to the family Alliaceae. It is originated in Central Asia and mainly used for food as well as medicinal purpose (Diriba*et al*., 2013).Garlic cultivated for its medicinal properties and this aspect is steadily on the rise worldwide. It lowers total plasma cholesterol, reduces blood pressure and decreases platelet aggregation (Sterling and Eagling, 2001). Most of the medicinal effects of garlic are attributable to a sulfur compound known as allicin (Schulz *et al*., 1998). According to British pharmacopoeia 1998, the minimum allicin content to ensure pharmaceutical and economical viability of garlic powder products is 4.5 mg/g.Globally, it occupies an area of 1,577.77 thousand hectares and production of 28,164.05 thousand metric tonnes with average productivity of 17.85 tonnes per hectare (FAO, 2017). In India, it is grown in an area of 319 thousand hectares with a production of 1862 thousand metric tonnes (NHB, 2019). In Himachal Pradesh garlic is mainly grown as cash crop covering an area of 4.95 thousand hectares and production of 8.49 thousand metric tonnes (Anonymous, 2018). Sulphur which is the fourth major plant nutrient after nitrogen, phosphorus and potassium is essential for building up sulphur containing amino acids (cystine, cysteine and methionine) in plant cells, particularly in the early stage of plant growth (Havlin, 2004). As such sulphur is a key nutrient in quality garlic production; therefore lack of its optimum supply in different plant parts limits the crop growth at any stage, resulting in yield reduction. Recently, studies have proved that amino acids can directly or indirectly influence the physiological activities in plant growth and development. Also, amino acids are well known as bio-stimulants which have positive effects on plant growth, yield and significantly mitigate the injuries caused by abiotic stresses. Sulphur is a constituent of enzyme nitrite reductase which is responsible for the reduction of NO_2^- in chloroplasts and thus reduces the accumulation of cancerous compounds like nitrates in vegetables. Sulphur deficient plants also had poor utilization of macro and micro nutrients. Sulphur is an essential macronutrient and at an optimum concentration accelerates the plant growth (Magray*et al*., 2017). Organic manures activate many species of living organism which release phytohormones and may stimulate the plant growth and absorption of nutrients. Organic manures, therefore has a significant role to play in the growth and development of garlic (Yoldas*et al*., 2011). Organic manure acts as an excellent substrate for soil microbes and increases the proportion of labile carbon and nitrogen, directly stimulating the population and activity of microorganisms. The increase in microbial population in the presence of organic manures may also be attributed to

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greater availability of organic carbon and mineralized nutrients for their proliferation and further cellular development (Marathe*et al*., 2012). Jeevamrut is a rich source of beneficial micro flora which support and stimulate the plant growth and help in getting better vegetative growth as well as good quality yield (Devakumar*et al.*, 2014).

Comment [w5]: Divide it to one or two paragraph. Statealso the problemclerly?

Material and Methods

Field experiment was conducted at Experimental farm of Horticulture Research and Training Station and KVK, Kandaghat, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during the rabi season of 2018-19. This experiment was laid out in Randomized Block Design (RBD) with fourteen treatments and three replications. The size of the experimental plot was 2.0 m × 2.0 m with spacing of 20 cm × 10 cm. The cultivar of garlic used for the present study was 'Kandaghat Selection'.In each treatment ten plants were randomly selected from each replication for recording morphological and biochemical parameters. ~~The observation of total~~Total soluble solids (TSS) was estimated using hand refractrometer. Allicin content of bulbs of different treatments from each replication were determined with HPLC by using the method of British pharmacopoeia 1998. This procedure has been described in detail in Baghalian*et al*. (2005).

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Treatment details:

List 1: Treatment no. with treatment details~~.~~

Treatment No.	**Treatment Details**
T_1	No application of fertilizers and Jeevamrit
T_2	100% recommended dose of NPK (125:75:60)kg/ha
T_3	100% recommended dose of NPK + 40kg S/ha
T_4	100% recommended dose of NPK + 50kg S/ha
T_5	100% recommended dose of NPK + 60kg S/ha
T_6	100% recommended dose of NPK + 40kg S/ha + 5% Jv* @ 1 L/m^2
T_7	100% recommended dose of NPK + 50kg S/ha + 5% Jv @ 1 L/ m^2
T_8	100% recommended dose of NPK + 60kg S/ha + 5% Jv @ 1 L/ m^2
T_9	75% recommended dose of NPK + 40kg S/ha

T_{10}	75% recommended dose of NPK + 50kg S/ha
T_{11}	75% recommended dose of NPK + 60kg S/ha
T_{12}	75% recommended dose of NPK + 40kg S/ha + 5% Jv @ 1 L/ m^2
T_{13}	75% recommended dose of NPK + 50kg S/ha + 5% Jv @ 1 L/ m^2
T_{14}	75% recommended dose of NPK + 60kg S/ha + 5% Jv @ 1 L/ m^2

*Jv = First jeevamrit drenching after 15 days of sowing and repeated at fortnightly interval (total 14 application) FYM @ 250q/ha applied in all the plots (Except T_1)

Preparation of Jeevamrit

Jeevamrit drenching at fortnightly interval and first drenching after 15 days of sowing was given. Table 1 shows the standardized techniques of preparing the Jeevamrit as suggested by Sreenivasa*et al*. (2010).

Table 1: Ingredients of Jeevamrit used for drenching

Ingredient	**Quantity**
Cow dung	10kg
Cow urine	10L
Jaggry	2 kg
Pulse Flour	2 kg
Fertile Soil	1 kg
Water	200 L

Flow chart for the preparation of Jeevamrut

Add fresh cow dung + Cow urine in a plastic drum

↓

Mix jaggery + pulse flour and live soil in water and make the final volume

↓

Mix all the ingredients by stirring clockwise (morning and evening)

↓

On the fifth day, filter the solution and filtrate is ready for soil drenching

↓

Jeevamrit 5 per cent was applied as soil drench at fortnightly interval and first drench was givenafter fifteen days of sowing, last application being fifteen days before harvesting

Statistical analysis. The experimental results were statistically analysed by using general linear model of the standard errors of the mean. The data obtained in Randomized Complete Block Design (RCBD) for each parameter were tested by ANOVA using MS-Excel and OPSTAT. The difference between the treatments was compared by critical difference (CD) at 5 per cent level of probability (confidence), wherever the results were significant. The calculated F-values were compared with tabulated F-value. When F-test was significant, CD was then calculated to find out the comparative effectiveness among different treatments.

Comment [w6]: Why don't used known statistical software

Results and Discussion

Growth and yield parameters

The plant height, number of leaves per plant, bulb weight, number of cloves per bulb, bulb diameter and bulb yield per hectare of garlic were significantly affected with the different treatments of integrated nutrient management.Plant height of garlic was significantly affected by application of sulphur and jeevamrit (Table 2). S is the chief constituentof several enzymes and amino acids which are required for chlorophyll synthesis and itincreases the uptake of N which is a chief constituent ofchlorophyll (Verma*et al.*, 2013). S deficiency causes accumulation of soluble N within the plant but prevents utilization of N (Charities &Carpentiers, 1956). Thus, increasing level of S in turn improved plantgrowth by meeting higher nutritional demand for plant growth.The results of are also support the findings of Jawagadi*et al.* (2012) who reported that integrated nutrient management improved soil fertility by increasing organic carbon, available N, S, Mn and Fe and improvement in nutrient availability resulted in significant increase in plant height.

Table 2:Effect of different treatments of integrated nutrient management on growth andyield

Tr. No.	Plant height (cm)	No. of leaves/plant	Days to harvest	Bulb weight (g)	Bulb diameter (cm)	No. of cloves/bulb	Peeling index (%)	Bulb yield (q/ha)
T_1	64.53	7.97	219.67	39.63	3.71	10.90	90.33	153.63

Comment [w7]: Better to specify the treatments than saying T1, T2, etc.

T_2	72.63	8.73	230.33	51.67	4.53	12.50	93.82	194.33
T_3	77.54	9.24	231.00	57.29	4.84	13.00	92.97	206.65
T_4	80.48	9.61	231.67	60.22	5.05	13.22	90.92	213.62
T_5	79.74	9.56	231.33	59.78	4.95	13.12	89.95	212.23
T_6	82.65	9.87	234.00	61.57	5.06	13.37	93.65	220.88
T_7	86.39	10.23	235.00	64.84	5.39	14.17	93.32	233.57
T_8	86.15	10.15	235.33	64.25	5.28	13.90	93.54	231.66
T_9	69.94	8.28	226.67	49.82	4.38	12.10	93.38	185.17
T_{10}	72.55	8.71	228.00	51.37	4.49	12.47	92.26	191.40
T_{11}	72.09	8.68	228.33	51.21	4.44	12.40	93.80	190.23
T_{12}	73.83	8.90	229.00	53.53	4.57	12.63	92.94	196.09
T_{13}	77.36	9.18	230.33	55.59	4.72	12.87	92.17	202.33
T_{14}	77.29	9.07	230.33	55.22	4.65	12.87	90.43	202.03
$CD_{0.05}$	2.38	0.52	2.16	1.88	0.19	0.86	NA	9.52

Number of leaves in a plant is directly correlated with the leaf area for photosynthetic activity and ultimately with yield. The photosynthates which are formed in the leaves are ultimately stored in the bulb as garlic is underground crop. So, there is a direct correlation of leaf number, photosynthates manufactured in the leaves and the carbohydrates stored in the bulb. Increase in number of leaves per plant under integrated nutrient management treatments might be due to steady release of nutrients throughout the crop growth period. The above findings are in conformity with the findings of Farooqui*et al*. (2009) and Anand*et al*. (2017). The application of jeevamrit might have increased the microbial population that may have led to improved nutrient availability there by, resulting in maximum number of leaves per plant. Findings are also supported by Chatoo*et al*. (2007). Increasing dose of sulphur and jeevamrit application had positive effect on number of leaves as were observed in treatment T_7, Similar results were also obtained by Verma*et al.* (2013) and Patidar*et al.* (2017).

The significant effect on bulb weight as a consequence of integrated nutrient management can be attributed to the increased nutritional status of the soil resulting in increased crop growth. This may be further attributed to favorable effect of organic sources on microbial activity and root penetration in soil which might have caused solubilizing effect on native nitrogen, phosphorus, potassium, sulphur and other nutrients.Maximum bulb weight in treatment T_7 (Table 2)might be due to the role of nitrogen on protein synthesis, chlorophyll and enzymatic activity; the role of P on root development, phosphor-lipid and phosphor- proteins formation as well as

due to the role of K on promotion of enzymes activity and enhancing the translocation of assimilates (El-Desuki*et al*., 2006). It might also be due to the role of sulphur in building up of sulphur containing amino acids in plant cells, particularly in the early stage of plant growth and also it is the fourth major plant nutrient after nitrogen, phosphorus, and potassium (Havlin, 2004). These results are also confirmed by Magray*et al.* (2017) and Chattoo*et al.* (2019).

Application of sulphur increases the uptake of N which is a chief constituent of chlorophyll. Due to this reason, a significant increase in chlorophyll content and other growth and yield attributeswas observed.The similar results also found byZaman*et al.* (2011), Verma*et al*.(2013), Damse*et al*. (2014) and Shete*et al*. (2017). Sulphur is essential for building up sulphur containing amino acids in plant cells, particularly in the early stage of plant growth and also it is the fourth major plant nutrient after nitrogen, phosphorus, and potassium (Havlin, 2004). Studies have proved that amino acids can directly or indirectly influence the physiological activities in plant growth and development. Also, amino acids are well known as bio-stimulants which have positive effects on plant growth, yield and significantly mitigate the injuries caused by abiotic stresses. Anand*et al*. (2017), Patidar*et al*. (2017) and Singh *et al*. (2018) also reported the similar effect of sulphur. Kurubetta*et al.* (2017) reported that the application of jeevamrit have significant effect on the yield parameters such as bulb weight, bulb diameter and number of cloves. Similar results of increase in yield were reported by Manjutha*et al*. (2009).

Quality Parameters

Farooqui*et al*. (2009) reported that the increasing dose of nitrogen increases the dry weight of bulbs and bulb yield up to 150 kg N/ha. Availability of nitrogen is of prime importance for growing plants as it is a major constituent of protein and amino acids. Similar observations have also been recorded by Yadav*et al*. (2003) and Banafar and Gupta (2005).Neelima*et al.* (2011) reported that there was a significant improvement in the growth and yield in tomato plant with the combined application of liquid organic manures such as jeevamrit compare to RDF alone. Patidar*et al*. (2017) reported that 50 kg sulphur per hectare with RDF significantly increase the dry matter content of the bulb. This might be due to role of sulphur in improving amino acids and that uptake of nutrients directly enhances the dry matter accumulation in the bulb. The similar results were also reported by Damse*et al.* (2014) and Anand*et al.* (2017).

Oleoresin is an extremely concentrated product containing all the flavouring ingredients soluble in the particular solvent. Oleoresin content decides the quality and market value of the particular variety.Oleoresin content was significantly enhanced with the increasing levels of sulphur (Table 3). These results are in accordance toJaggi(2004), Banafar and Gupta (2005) and Farooqui*et al*. (2009). According to Sindhu and Sekhon (2000), the improvement in the quality attributes due to various fertilizers treatments is directly correlated with physico-chemical and biological properties of soil which enables roots to proliferate more resulting into better uptake and utilization of nutrients required for enhancing the quality of crop. The present findings are consistent with those of Mridula and Jayachandran (2001) and Velmurugen*et al*. (2008).

Singh *et al.* (2018) and Chattoo*et al.* (2018) also reported the similar trends in total soluble solids with the application of sulphur. Sulphur plays important role in plant's growth and development. It is involved in the synthesis of amino acids like cystine, cysteine, methionine, etc. It is also responsible for characteristic taste and smell of garlic like onion and mustard (Tisdale *et al*., 1985). Jeevamrit application also enhanced the total soluble solids content due to the conversion of organically bound sulphur to the inorganic form.

Table 3:Effect of different treatments of integrated nutrient management on Quality parameters

Tr. No.	wt of unpeeled 100 cloves (g)	Dry matter content (%)	Oleoresin content (%)	TSS (°Brix)	Sulphur content (%)	Allicin (mg/g)
T_1	309.33	36.53	0.74	32.13	1.02	4.73
T_2	373.33	39.23	1.08	33.77	1.11	5.28
T_3	400.00	41.00	1.30	34.80	1.31	5.76
T_4	418.33	42.25	1.42	35.30	1.42	5.94
T_5	414.00	42.23	1.39	35.27	1.42	5.91
T_6	421.67	42.98	1.42	35.47	1.38	5.95
T_7	445.67	44.15	1.60	36.30	1.50	6.19
T_8	443.33	44.05	1.61	35.97	1.52	6.15
T_9	354.67	38.70	0.99	33.20	1.17	5.00
T_{10}	370.33	39.08	1.10	33.60	1.26	5.15
T_{11}	366.00	39.01	1.09	33.53	1.28	5.12
T_{12}	370.00	40.44	1.14	33.83	1.23	5.23
T_{13}	384.33	40.95	1.28	34.13	1.34	5.36
T_{14}	382.33	40.91	1.25	34.17	1.35	5.33
$CD_{0.05}$	17.60	0.83	0.14	0.63	0.06	0.23

Comment [w8]: Similar comments as given in the above table.

Allicin content of the bulb increased significantly with different treatments of integrated nutrient management might be due sulphur application and increase in inorganic sulphur in the soil. That ultimately enhances the sulphur containing compounds.

CONCLUSION

It can be concluded that among different treatments of integrated nutrient management the treatment comprising of 100% recommended dose of NPK + 50 kg S/ha + 5% Jv @ 1 L/ m^2 (T_7) performed best for most of the parameters under study.

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